# JOURNAL

SEPTEMBER, 1932

WM. J. McKEEN

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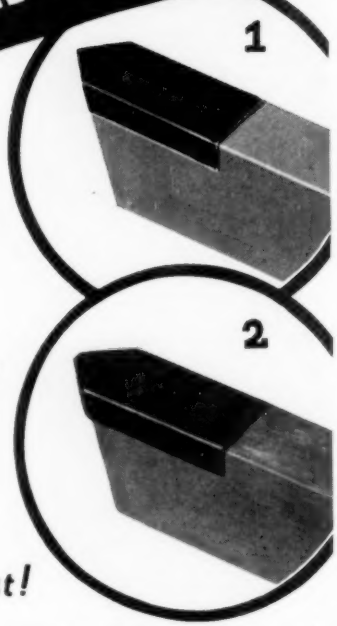


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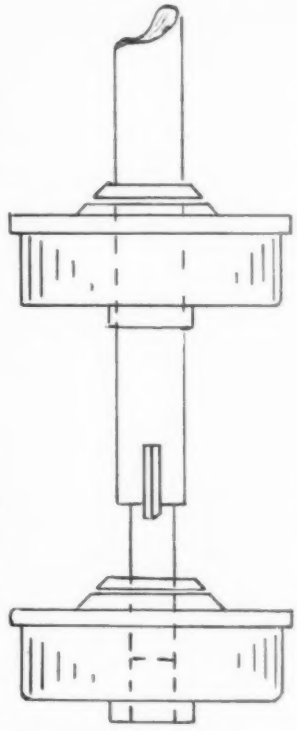

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# A. S. T. E. Journal

*Published by the American Society of Tool Engineers*

8316 Woodward Avenue

Detroit, Michian



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VOL. I. SEPTEMBER, 1932 No. 5


## Table of Contents


| | | |
|---|---|---|
| Committee Reports | Page | 6 |
| Editorial Page | " | 7 |
| A Trip through the Chrysler Plant | " | 8 |
| Tool Engineering Bulletin No. 5 | " | 11 |
| Tool Engineering Bulletin No. 6 | " | 12 |
| A Tool Engineering Project | " | 13 |



Owing to the nature of the American Society of Tool Engineers organization, it cannot be responsible for statements appearing in the Journal either as advertisements or in papers presented at its meetings or the discussions of such papers printed herein.



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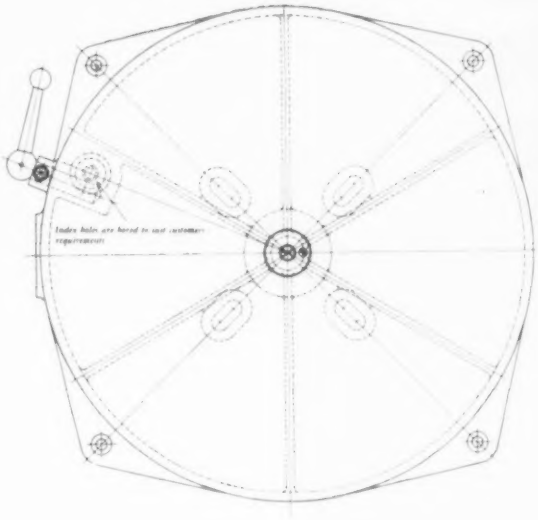
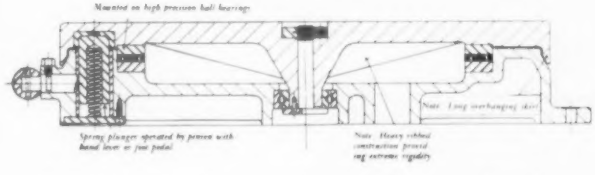
INDEX

TABLES

WITH LAMB MULTIPLE SPINDLE HEADS MAKE AN IDEAL APPLICATION ON PARTS WHERE MULTIPLE OPERATIONS ARE REQUIRED. SUITABLE FIXTURES MOUNTED ON LAMB BALL BEARING INDEX TABLES INSURE ACCURATE INDEXING WITH EASY OPERATION.





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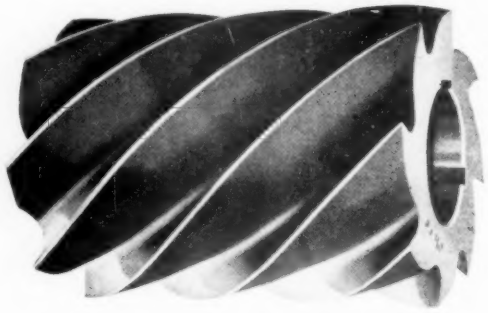

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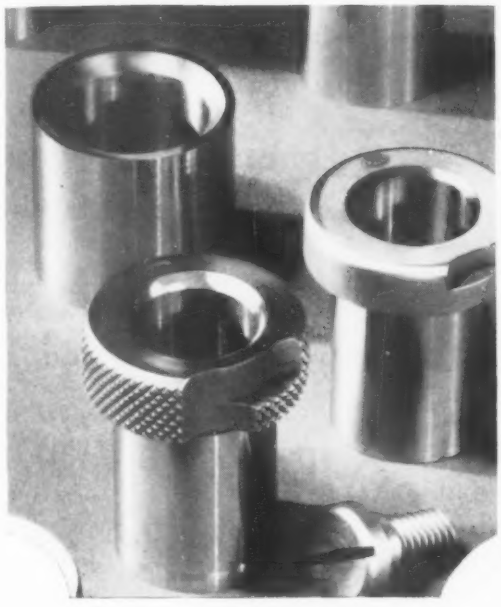

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# NEXT MEETING

The next general meeting will be held Thursday, September 8, 8 o'clock, at the Detroit Leland Hotel.

Mr. C. A. Birkebak, Mechanical Engineer for Ex-Cell-O Aircraft and Tool Corporation of Detroit, is to be the guest speaker for the evening. He will describe the development and operation of the Ex-Cell-O Precision Boring Machine for high production precision parts.

Mr. Birkebak is a graduate of the University of Copenhagen in Mechanical Engineering. Upon leaving school he became associated with the White Star Steamship Lines as engineer. Later he joined the Allis-Chalmers organization as an Erecting Engineer, testing and installing steam turbines and diesel engines. From here, he took up post graduate work at Purdue University, which was interrupted by the World War.

MR. C. A. BIRKEBAK

Returning from the service he became identified with different organizations in the cutting tool and special machine field, specializing on hydraulic equipment. Early in 1929 he became Mechanical Engineer for Ex-Cell-O where he has devoted his activities to the Precision Boring Machine.

## REPORT OF NEW CHAPTER COMMITTEE

The committee has formulated several plans for the organization and installation of chapters in other cities. These plans have been submitted to the Board of Directors and are to be acted on at a special meeting in the near future.

NEW CHAPTER COMMITTEE

*Left to right*: Mr. L. K. Rosenberg, Tool Engineer, Plant Layout, General Motors Truck Corporation, Pontiac; Mr. T. B. Carpenter, Assistant Chief Tool Designer, General Motors Truck Corporation, Pontiac; Mr. J. F. Slavik, Tool and Sales Engineer, Warner and Swasey Company, Detroit Branch.

**— ANNOUNCEMENT —**

The general meeting is held the second Thursday of each month. All copy for the current issue of the Journal must be in by the 20th of the preceding month.

# EDITORIAL PAGE

## DON'T BE TOO OPTIMISTIC

You can't, just by the searing action of a powerful thought, remove a cancer from your liver. However, Coué was right in many ways. So was Mary Baker Eddy. Physicians say worry causes the secretion of certain harmful juices which result in ulcers on the inside lining of the stomach. Why have ulcers?

Thoughts may be more deadly than lethal gas. The billion and a half persons on earth are absolutely controlled by thought. Their situation is pitiful only when they are controlled by the thoughts of just one individual or a clique. It isn't easy to think. It's easier to follow the great thinkers. This habit of looking for saviors has caused too much trouble already. Congress should pass a law prohibiting this practice to an extent of more than ½ of 1 per cent. Each man's salvation is in his own mind. Each must save himself. Thus only can we all be saved. Be stoical!

Couéism, Eddyism, Stoicism, and all other isms are harmful only when we try to apply them to all the ills of humanity. The cause of all man's woes is that he simply cannot be temperate, medium, moderate. It's just as wrong to be optimistic as to be pessimistic about everything. There is a time to be optimistic and a time to be pessimistic about a few things at a time. Don't be optimistic about everything or pessimistic about everything. Nothing is wholly right or wholly wrong—always, everywhere. It's wholly wrong to wear a bathing suit to your mother-in-law's funeral, but entirely correct and proper to wear one on the beach if you're built that way.

We have discovered antidotes for most poisons. Too much fear is the poison that brings on an excess of pessimism. The antidote is courage, which produces a mental excess of optimism, which neutralizes some of the pessimism and results in mental equilibrium.

The world has recently, and still is, suffering from an overdose of fear and pessimism. It has been considered poor taste to be optimistic. It will soon be a breach of etiquette if you're pessimistic. Optimism is the vogue now. It has just begun to stir the leaves like the gentle breeze at the dawn of day. It will soon be sweeping around the world like a rushing, mighty wind. We'll be just as haywire then as we are now.

Of course, looking into the future is like looking into a mirror; you see what you bring, so I must be careful of what I say of the future, or you'll tag me as a pessimist. But I would like to call your attention to the many overtime hours of labor which each and everyone of us tool engineers, designers, and draftsmen will soon be complaining about.

With our motors in the rear end, our contours streamlined and floating on dirigible balloons, with production doubled by tantalum and tungsten carbide—well, it's about time for tear drops—and curtain drops.

## NEWS NOTES OF THE INDUSTRY

The Adam Opel Company, General Motors' subsidiary in Germany, has just announced a new six-cylinder model of interesting streamline design. While the lines are approaching the ultimate in streamline designing, they are not too radical, from fear that the body shaping might prove unpopular.

The six cylinder side-valve engine is a bore and stroke of 65 mm. and 90 mm. and delivers 32 horsepower.

A line of tipped cutting tools of cobalt alloy, welded to carbon steel shanks, manufactured by a Manchester, England, company is now being distributed in this country. It is claimed that the cobalt alloy in these tools has properties between high speed steel and tungsten carbide, combining toughness with hardness. The shanks are recessed to an acute angle to receive the tips, this giving a backing approximately normal to the cutting pressure. A wide variety of shapes and sizes may be had.

"The spirit of optimism that is sweeping the country is beginning to be felt by the machinery trade," reports the AMERICAN MACHINISTS.

"From Indianapolis comes word of an immediate reaction to the home loan discount bill. Plants are taking on men, inquiries are better and there are more orders being booked. Not much is stirring in Pittsburgh, although two U. S. Steel Corporation plants, long down, have reopened."

## FUTURE EVENTS

August 22-26—American Chemical Society Convention, Denver, Colorado.

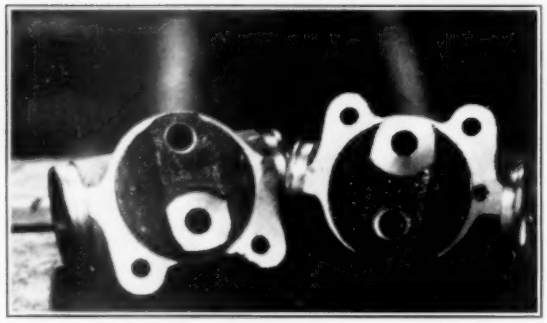
August 30—September 1—S.A.E. Aircraft Meeting, Cleveland, Ohio.

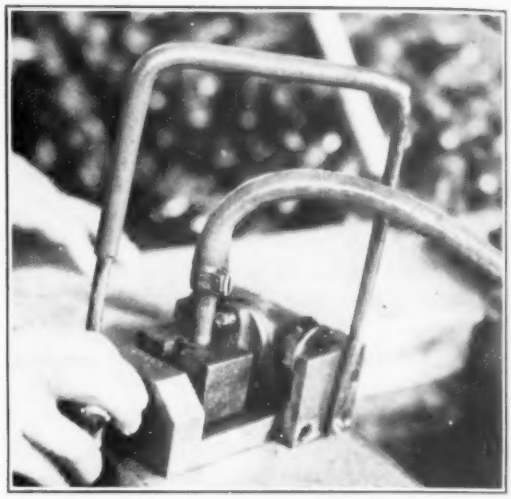
October 3-7—National Metal Congress, Buffalo, New York.

December 5-9—Annual Meeting A.S.M.E.

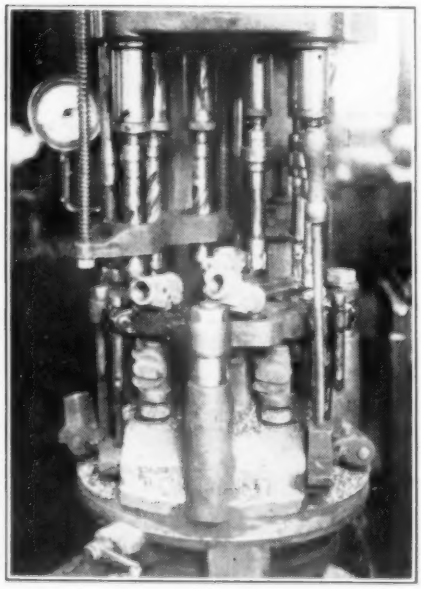
# A TRIP THROUGH A SECTION OF THE CHRYSLER PLANT

Conducted and Described by
Edward C. Lee,
Chief Tool Designer,
Chrysler Corporation.

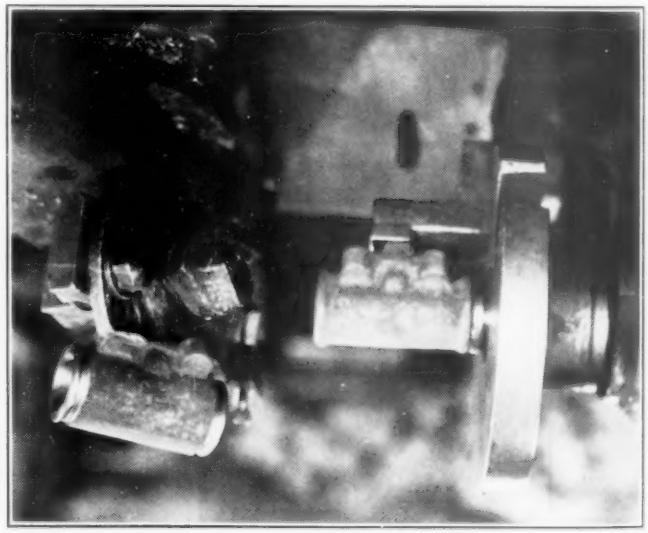




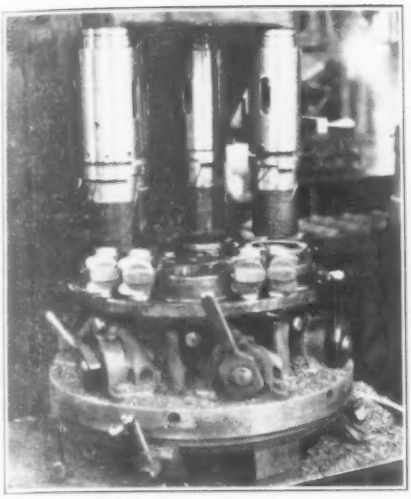
On this trip you will be shown the machine tools, fixtures, tools, and setups for machining four wheel brake cylinders (above left). These castings are made of close grained cast iron. When finished the bores must be free from all blow holes and porous spots. The castings are annealed to soften any hard spots and to equalize the strains. In testing them for leakage (upper right), alcohol is used with a pressure of 1200 lb. per square in.



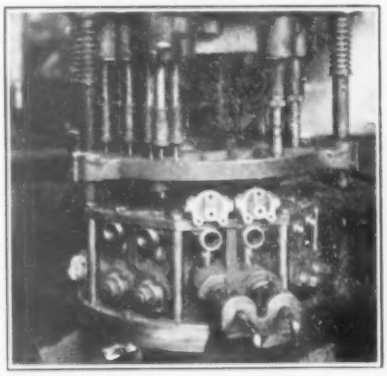
Oper. No. 1. Core drill and ream bores, leaving 0.008 to 0.010" for grinding. Automatically controlled hydraulic feed drill press with a six spindle head.



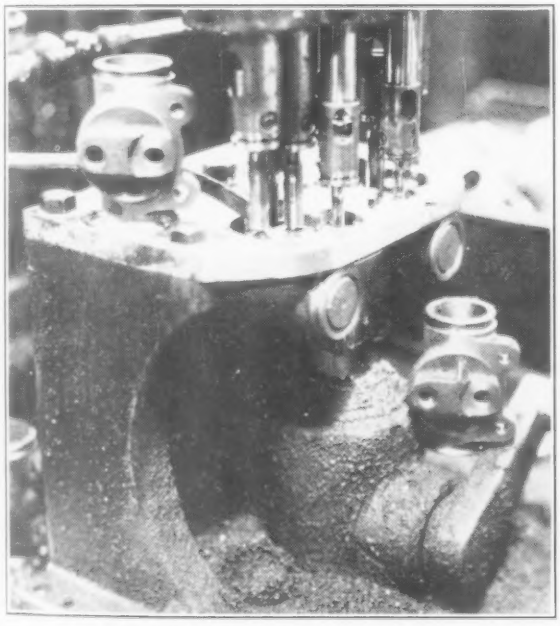
Oper. No. 2. Rough turn, face, and groove. The grooving is done to hold in place rubber protectors. A lathe equipped with two tool blocks. The rear block holds stellite tools for facing and rough turning, and the front block holds a circular forming tool for the grooving operation. The cuts are short (not over 5 seconds), so hand feed is used. The machine is so arranged that the spindle is started and stopped by the operation of the lathe carriage.



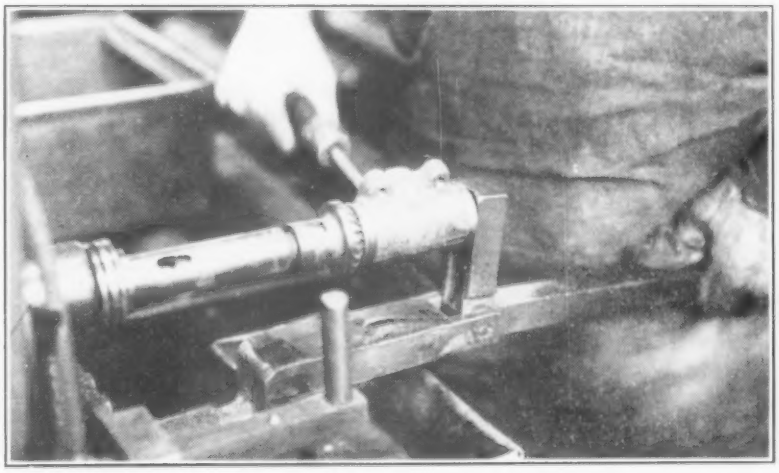
Oper No. 3. Hollow mill and face boss for inlet connection. Hydraulically operated drill press with four spindle head. Two spindles roughing roughing while two spindles are finishing. Three station fixture permitting the operator to load one station while machining. Two cylinders completed at each indexing of the table.



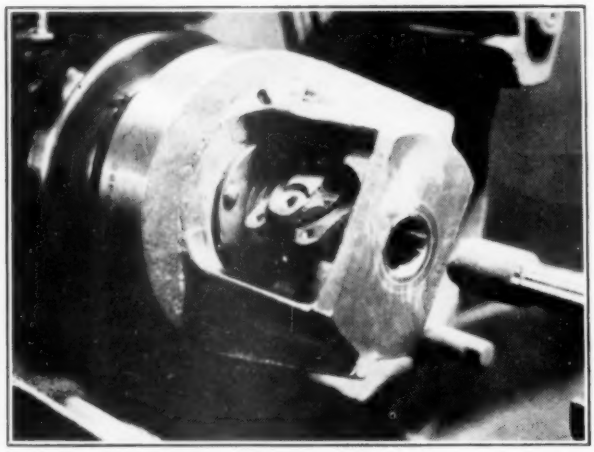
Oper. No. 4. Drill all holes, rough and finish spot-faceseat, and countersink one hole. Drill press equipped with sixteen spindle head and bushing plate. Seven station indexing table carrying fixtures to hold the cylinders, locating from bosses finished in previous operation.



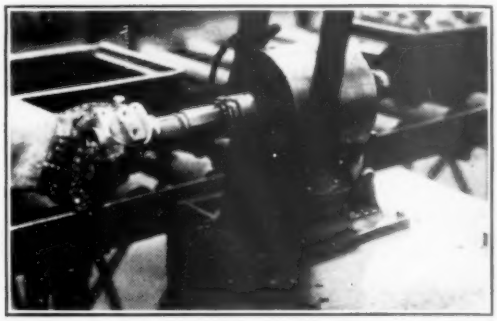
Oper. No. 5. Tap four holes. Pneumatic tapping machine equipped with an eight spindle head. The cam operated, quick clamping fixture holds two cylinders, located by the bores and inlet connection bosses. Production rate 340 per hour. At this point the castings receive a thorough washing to remove all chips and dirt before the chamfering operation, because the chamfering must be concentric with the bores.



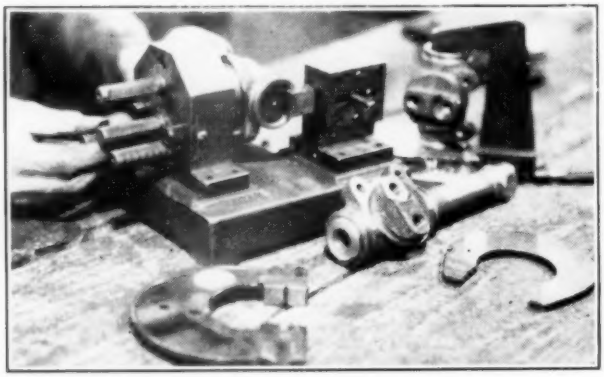
Oper. No. 6. Chamfer both ends of the cylinder bore. A piloted chamfering tool is used to hold concentricity because the cylinders are located from this chamfer for grinding.



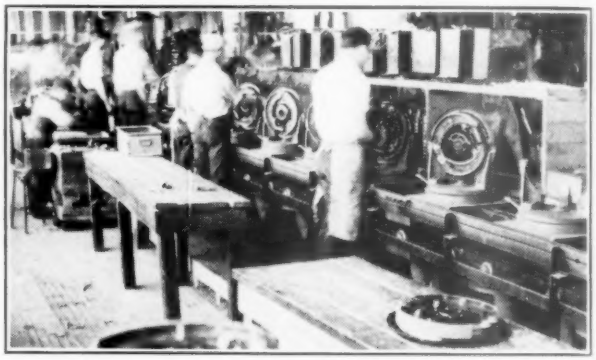
Oper. No. 7. Grinding the bores. Internal grinding machine. Work is held in place by spring pressure.



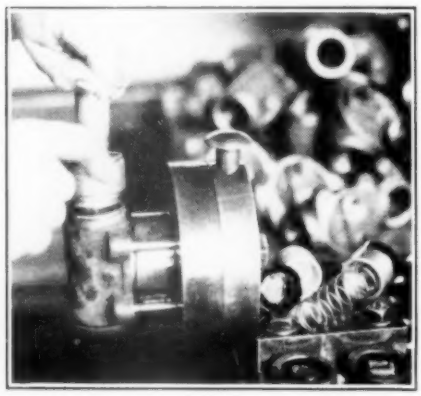
Oper. No. 8. Lapping the bores. Lap is covered with abrasive paper held on by rubber bands. Another washing operation takes place before inspection.



Oper. No. 9. Inspect. Check all threaded holes for diameter and pitch of threads. Gage bores and check all holes for spacing and center distance in relation to the bores.



The brake assembly line. The assembling fixtures are mounted upon a double track built of angle iron, and are moved by the conveyor chain. The inspection Operation No. 9 is particularly thorough because it is not contemplated that the brakes will require any repairs that will necessitate the disassembly of the cylinders and pistons during the life of the car.



Oper. No. 10. Assemble cylinders, pistons, springs, and rubber protectors.

## EASY DRAWING METHOD

McCauley and Madison Inc., of Detroit, Michigan, have developed a pad which makes drawing and sketching easy, and have aptly named it E-Z DRAFT.

It is a combination of plates on bristol boards, ruled isometrically on one side with standard ⅛" cross section lines on the other, either side having horizontal and vertical lines at inch intervals. The outfit consists of the cover, pad, and plates. The cover is made of artificial leather in sizes convenient for portfolio or bag, and contains a pocket convenient for carrying sketches, etc.

The pad or refill contains 100 sheets of durable transparent paper from which blue prints can be made.

By inserting a ruled plate under the top sheet of the pad the user has lines to enable him to make true drawings or sketches. The drawing will contain no cross section lines.

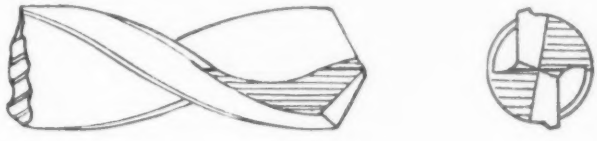
# Tool Engineering Bulletin No. 5

## DEEP HOLE DRILLING

In the construction of many modern mechanisms and apparatus, and particularly in the construction of automotive engines, it is required that oil shall be conveyed under pressure to the various bearings and moving parts. This usually calls for the drilling of comparatively small diameter and very deep holes thru some of the members. Due to these requirements a new technique of deep hole drilling, on a production basis, has been developed.

If the holes to be drilled are ¾" diameter or larger, an oil hole drill can be used to advantage, that is a drill with an oil hole thru its entire length so that fluid can be carried to the cutting edges. If on the other hand, as is usually the case, the holes to be drilled are from $^{3}/_{16}$" to ⅜" in diameter, this type of drill cannot be used. For the latter purpose, special deep hole drills have been designed. These differ from ordinary twist drills principally in that the web is much heavier and the spiral somewhat faster. The web in some cases may be 40% of the diameter of the drill.

This in turn necessitates a special type of sharpening so as to effectively break up the chips and to eliminate undue end thrust on the drill. The most approved type of sharpening is shown in the sketch on this page.



It should be noted that the drill is first sharpened in the conventional way, after which the angular cuts are made with a grinding wheel having a sharp corner.

Some remarkable results have been achieved with drills of this type. As an example, holes ¼" diameter and 4½" deep, in .35 Carbon Steel, are being drilled in from 1¼ to 1½ minutes. It is only necessary to lift the drill out one or two times in the entire length of the hole. This operation is being performed with the drill running at 65 surface feet per minute. Feeding is done by hand, and will average about .005" per revolution of the drill.

Inasmuch as the construction of this type of drill must be varied to suit conditions, and materials, it is recommended that deep hole drilling problems be submitted for engineering advice.

Courtesy of C. J. Oxford.

National Twist Drill & Tool Co.
Detroit, Mich.

# Tool Engineering Bulletin No. 6

## THE TORSIONAL STRENGTH OF TWIST DRILLS

The data given below were obtained as a result of extensive tests conducted in the Engineering Laboratories of the University of Michigan. The investigation was prompted by a desire to learn something about the torsional deflection of drills under load, and also to establish the relation of the average torsional load on a drill, to the load at which the drill would break.

The tests were carried out on a Tinius Olsen torsion testing machine with the shank of the drill in a taper socket. Deflection indicators were arranged both at the end and at the middle of the fluted portion of the drill. The tests recorded here were conducted with 1″ diameter High Speed Steel Twist Drills of standard design.

The results indicated that twist drills deflect, torsionally, even under ordinary drilling loads, though the deflection is comparatively small. Further, it was found that the torque required to operate a drill under ordinary conditions is only about fifteen percent of the torque at which the drill will break.

The average torque load, when drilling steel with a 1″ diameter drill, is about 800 inch pounds. The deflection, at the point, under this load when recorded at a 30 inch radius showed a movement of 1.7″, or approximately 0.030″ at the periphery of the drill.

The average torque at which 1″ High Speed Steel Drills would break was found to be 5500 inch pounds with a deflection of about ⅛″ at the drill periphery.

From these tests, it was concluded that this size of drill has ample strength to withstand any torsional strains to which it is apt to be subjected. Should the torsional load increase, due to dulling, from 800 inch pounds to say 1200 inch pounds there would still be a safety factor of 4½ plus.

It was further concluded that in view of the amount of deflection shown, the increase in cross section of a drill may be desirable in many cases in order to eliminate chatter, which in the case of a drill is nothing more or less than torsional deflection.

Courtesy of C. J. Oxford.

National Twist Drill & Tool Co.
Detroit, Mich.

**EDITOR'S NOTE**

A member of the Editorial Committee recently received a letter from a well known engineer from the East who made the kindly suggestion that articles of a strictly tool engineering nature should occupy a greater proportion of the space in the Journal.

Repeated requests have been made in the editorial pages of this Journal for contributions from tool engineer members, so that everyone might reach an understanding of all the intricacies of Tool Engineering. The Committee has had to take what it could get—gratis—and now has enough material on hand to publish several issues of the Journal, but unfortunately this material does not represent the kind of tool engineering material we have been looking for.

The fact that so much material has been contributed indicates a splendid spirit of cooperation, for which the Committee is truly grateful. The Committee feels that the crazy-quilt appearance of the Journal in the past has been due to the fact that in soliciting articles it has not been sufficiently explicit in designating the types of articles preferred.

The thought came to one of the Committee that the best way to indicate the type of article wanted was to make up a portrayal of the processes of tool engineering step by step in a hypothetical plant, which should be printed as a prototype to be followed by contributors. While the imaginary project should cover every phase of the subject, obviously contributors might not be able to follow the original example from end to end, but could elaborate certain phases of the subject.

In casting around for such an example, the story beginning on this page was presented by a group of junior members, and immediately passed by the Committee as well serving the purpose.

The June issue of the Journal carried an appeal to the junior members to "get busy and start some real junior activity," and also the admonition to the seniors to "look to your laurels." With enthusiasm characteristic of youth, the juniors have responded by contributing this thesis exemplifying their conception of what Tool Engineering is. Except for the guidance of the instructors at their school, all the work on this paper, including the writing and preparation for publication, has been done by this group of budding tool engineers, whose picture is appended on the second page of the article. Every jig and fixture, and the floor layout of the plant, were designed by this group of juniors, who made all the drawings used in the article.

While the Committee is in no way responsible for possible errors in the article, every part of it has been studied carefully by at least one member of the Committee, and we believe that the general applications of theory and formulae are sufficiently accurate to merit the reader's close study. If errors are found, or better methods of solving any of the problems are known, the Committee would appreciate the opportunity of publishing the better way.

# A TOOL ENGINEERING PROJECT

By SVERRE BERG, FLOYD CARLSON, CLARENCE ERICKSON, HERBERT ROYLE, LEONARD SPRENGER, TOM TOMAKICH, KENNETH WATSON, and LOUIS WOKAS.

We, the graduating class of the Detroit College of Applied Science for the year 1932, submit the following co-operative project as our graduation thesis and as an embodiment of what, in our opinion, constitutes Tool Engineering.

The problem put before the class of Tool Engineering students was: Draw up a complete set of plans for efficiently and economically producing the bench drill press shown in Fig. 1 in quantities of 1000 a day, choosing the appropriate machines, designing the necessary fixtures, planning the plant layout, and determining the cost of production. We were to assume that we were launching a new manufacturing enterprise, and that our imaginary plant had no history or records of past manufacturing practices and costs. However, we were required to draw freely from the experience and accumulated data of existing manufacturing establishments. Additional assumptions we were given to work with were as follows: production was to be 300,000 a year, 1000 a day on the basis of a 300 working day year, an eight hour day, and a six day week; we were to buy the land and have the plant built to suit our requirements; piece rates were to be arrived at by setting up certain standard base rates for various types of work; and we were to have unlimited freedom in our choice of machines and tools, only economy, as determined by comparative cost calculations, to be our guide in equipping the plant, that is, economy without sacrifice of the quality of product desired.

At first sight, it might seem that our problem was considerably different from that encountered by the active Tool Engineer on the job. But essentially, the problem confronting the practicing Tool Engineer is the same as the problem confronting the embryo Tool Engineer, for both involve such fundamental matters as choice of machines,

*Left to right:* Sverre Berg, Leonard Sprenger, Clarence Erickson, Tom Tomakich, Floyd Carlson, Louis Wokas, Kenneth Watson, Herbert Royle.

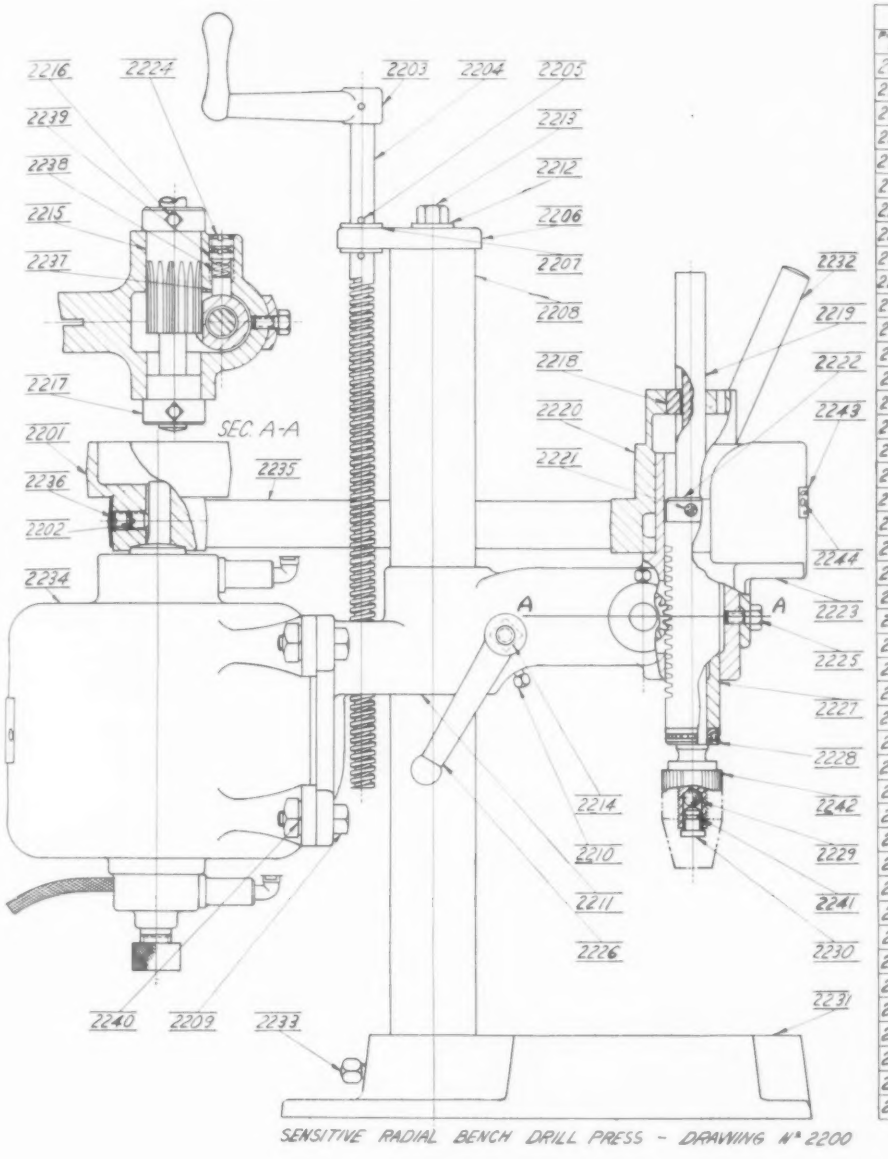
design of fixtures, labor costs, machine hour rates, machine loading, and production costs.

But, in this connection, let it be clearly understood that we do not claim credit for having created an ideally perfect manufacturing plant on paper. It is not our intention to hold up this project as an ideal specimen of production planning, and, far from desiring to squelch any adverse criticism of any of the details, or even the whole, of our project, we shall eagerly welcome all the discussion and criticism that may be forthcoming.

Obviously, it would be both impracticable and tedious to print the complete project in all its details, including all the operation and data sheets which of necessity were made up for each detail, and all the individual calculations by which such items as machining times and labor costs were obtained. Hence, an attempt will be made in the following pages merely to give a cross section of this several months' project. It is hoped, however, that nothing essential has been omitted, and that the material chosen for publication is so representative of the various phases of the project that the reader may, if he so desires, fill in the missing details for himself by merely following through the typical procedures outlined. In other words, most of the omissions will be found to be matters of repetitive detail.

The plan of presentation followed has been to give several distinct, separate descriptions of the various phases of the work, rather than one complete, uninterrupted narrative. For example, the account tracing the path of the raw materials through the plant until they emerge as a finished drill press, will leave out the description of the methods used in computing conveyor speeds, machining times, labor costs, and so on. These items will be dealt with separately under appropriate headings. The several topics discussed will be presented in the following order: a mechanical drawing of the drill press together with the bill of material (Fig. 2); operation sequences and operation times, and how they were arrived at in the case of two of the most typical

Fig. 1. The Bench Drill Press manufactured in the plant.




| PART No. | BILL OF MATERIAL NAME & STOCK SIZE | No. REQD | MAT. |
|---|---|---|---|
| 2244 | 1/8 DIA. X 3/16 RIVET | 2 | STD. |
| 2243 | NAME PLATE | 1 | STD. |
| 2242 | 0-3/8 ALMONT DRILL CHUCK | 1 | STD. |
| 2241 | RETAINER SPRING | 1 | STD. |
| 2240 | 5/16 DIA. LOCK WASHER | 4 | STD. |
| 2239 | 1/2-13 USS. X 3/8 HDLESS SET SCR. | 1 | STD. |
| 2238 | COIL SPRING | 1 | STD. |
| 2237 | 5/16 DIA. X 1/2 BRASS PLUG | 1 | STD. |
| 2236 | 3/8-16 USS. X 3/8 HDLESS SET SCR. | 1 | STD. |
| 2235 | 1" X 20" ENDLESS FABRIC BELT | 1 | STD. |
| 2234 | MOTOR No. 31061-1/4 HP.-GEN. ELECT. | 1 | STD. |
| 2233 | 3/8-16 USS. X 1 SQ. HD.-SET SCR. | 1 | STD. |
| 2232 | FEED LEVER-5/16 DIA. X 14 7/8 | 1 | C.R.S. |
| 2231 | BASE - PATT. No. 2231-P1 | 1 | C.I. |
| 2230 | THRUST PIN-1/2 DIA. X 5/8 | 1 | C.R.S. |
| 2229 | HARDENED BALL - 3/8 DIA. | 1 | STD. |
| 2228 | THRUST BEARING - 3/8 DIA. | 1 | STD. |
| 2227 | RACK - PATT. No. 2227-P1 | 1 | C.I. |
| 2226 | LOCK LEVER - PATT. No. 2226-P1 | 1 | C.I. |
| 2225 | 5/16-18 USS. X 1/2 HEX HD. SCR. | 1 | STD. |
| 2224 | 1/2-13 USS. X 3/8 HDLESS SET SCR. | 1 | STD. |
| 2223 | GUARD - PATT. No. 2223-P1 | 1 | C.I. |
| 2222 | SPINDLE COLLAR - 1 1/16 DIA. X 5/8 | 1 | C.R.S. |
| 2221 | 1/4-20 USS. X 1/4 HDLESS SET SCR. | 1 | STD. |
| 2220 | SPINDLE PULLEY - PATT. No. 2220-P1 | 1 | C.I. |
| 2219 | SPINDLE - .635 DIA. X 11 3/8 | 1 | C.R.S. |
| 2218 | KEY - 1/8 X 5/16 X 1 1/8 | 1 | STD. |
| 2217 | ADAPTER BUSH - 1 5/16 DIA. X 1 1/8 | 1 | C.R.S. |
| 2216 | 5/16-18 USS. X SQ. HD. SET SCR. | 2 | STD. |
| 2215 | FEED PINION - 1 7/8 DIA. X 2 3/4 | 1 | C.R.S. |
| 2214 | 3/8-16 USS. X 2 1/4 SQ. HD. SCR. | 1 | STD. |
| 2213 | 3/8-16 USS. X 1 HEX HD. SCR. | 1 | STD. |
| 2212 | WASHER - 3/8 DIA. | 1 | STD. |
| 2211 | ARM - PATT. No. 2211-P1 | 1 | C.I. |
| 2210 | 1/4-20 USS. X 3/4 SET SCR. | 1 | STD. |
| 2209 | 5/16-16 USS. X 1 BOLT | 4 | STD. |
| 2208 | COLUMN - 1.760 DIA. X 18 | 1 | C.R.S. |
| 2207 | WASHER - 1/2 DIA. | 2 | STD. |
| 2206 | CAP - PATT. No. 2206-P1 | 1 | C.I. |
| 2205 | DOWEL PIN - 1/8 DIA. X 1 | 3 | STD. |
| 2204 | ADJUSTING SCR. - 1/2 DIA. X 14 3/8 | 1 | C.R.S. |
| 2203 | ADJ. SCR. HANDLE - PATT. No. 2203-P1 | 1 | C.I. |
| 2202 | 3/8-16 USS. X 3/8 HD. LESS SET SCR. | 1 | STD. |
| 2201 | MOTOR PULLEY - PATT. No. 2201-P1 | 1 | C.I. |

SENSITIVE RADIAL BENCH DRILL PRESS - DRAWING No. 2200

Fig. 2. Mechanical Drawing and Bill of Material for Drill Press.

details of the drill press; the redesign of one of the details for greater economy in production; the economics of machinery selection and fixture design; a description of the layout of the plant, material handling, and the routing of the details in the various stages of completion through the plant; conveyors; and, finally, cost analysis.

A word as to the methods of work followed by the student. Each member of the class has, at some time or other, worked on each of the phases of the problem outlined above. The work was carried on by small committees of two or three members, each committee specializing in one particular branch of the work. For example, there were the machine, the tool, the fixture, the executive, the gage committees, and so on. Through a system of revolving membership, each individual in the class had several opportunities of working on every branch of the project.

We wish to acknowledge our indebtedness to the following individuals and companies for generously supplying us with information and electrotypes of machines, and cooperating with us in many other ways, enabling us to complete this project: Mr. Hughes, Canedy-Otto Manufacturing Co.; Mr. Campbell, Lee Machinery Co.; Mr. DuBois, Potter and Johnston Machine Co.; Messrs. Heidlinger and Dowd, Leland-Gifford Co.; Mr. Nieman, Chas. A. Strelinger Co.; Mr. Nielsen, Gardner Machine Co.; Mr. Stokes, Sebastian Lathe Co.; Mr. Slavik, Warner and Swasey Co.; Mr. Wells, Motch and Merryweather Machinery Co.; Mr. Winter, Cincinnati

Milling Machine and Cincinnati Grinders Inc.; Mr. Frye, Landis Tool Co.; Mr. Hodges, Barber-Colman Co.; Mr. Livingstone, American Broaching Machine Co.; Mr. Martin, Logan Co.; Major Woofter, Swift Electric Welder Co.; Mr. Swartz, George A. Gloor Tool Co.; Mr. Peterson, Kelley Reamer Co.; Mr. Spencer, Detroit Boring Bar Co.; Mr. Plant, Austin Co.; Mr. Anderson, General Electric Co.; Mr. Kent, Carboloy Co.; Mr. Dunn, E. F. Houghton and Co.; Mr. English, Thompson Products Co.; Mr. Pott, English and Miller Co.; Mr. Voorheis, Jos. E. Barrett Co.; The Restrick Lumber Co.; Mr. Patterson, Avey Drilling Machine Co.; Mr. Ferrington, Graham-Paige Motor Co.; Mr. Siegel, Packard Motor Co.; and all other individuals and companies who have rendered us assistance in any way, and whom, through oversight may not be listed.

## OPERATION SEQUENCE, DETERMINATION OF OPERATION TIMES, AND FIXTURE DESIGN FOR COLUMN

The cold rolled steel stock for the column (Fig. 3) is ordered 0.010" oversize, so that a standard reamer can be used for reaming the column hole in the base. If 1.750" diameter stock were ordered, the column, after grinding, would be smaller than this figure, and a special reamer would be required for reaming the hole in the base. It was necessary to grind the stock because the standard commercial tolerance on cold rolled steel shafting stock is +.000 —.002", which was more than we could allow on this particular fit.

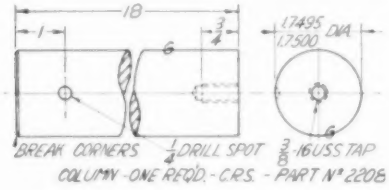



Fig. 3. Column of Drill Press.

A hydraulic feed cut-off saw, shown in Fig. 4, was chosen for the operation of sawing the bar stock. The following consideration influenced the selection of this machine: The compensating hydraulic feed is of great value because it keeps the horsepower input steady, and makes an infinite number of feeds obtainable while the machine is cutting. The feed pressure is constant and easily adjusted to suit the cross section to be cut. The deeper the saw blade enters the cut, the more teeth there are in contact, thereby increasing the feeding pressure required. On a round bar the feeding resistance decreases as the center of the material is passed. The feed pressure being uniform, the feed rate changes in accordance with the varying resistance pressure and the cross section. This is shown graphically by the heavy and light sections in Fig. 5.

According to data furnished by the manufacturers of the cut-off machine, a cutting speed of 70' per minute may be used in sawing cold rolled steel. The production rate area, for steel with a tensile strength of 70,000 lb. per square inch, is given as 19 square inches per minute. Dividing 60 seconds by

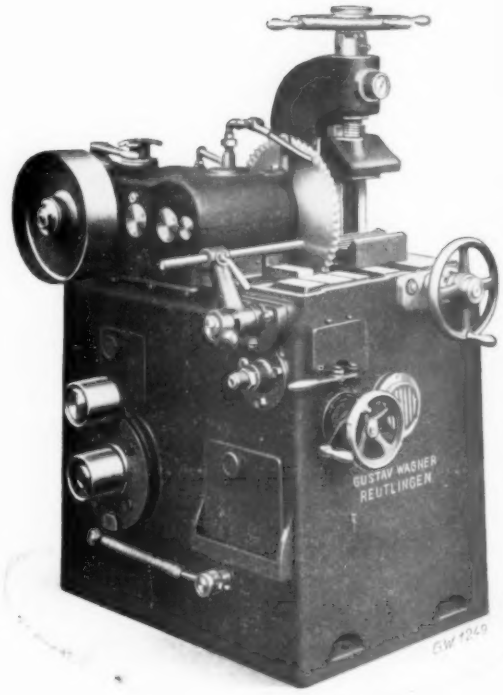



Fig. 4. Wagner Cut-Off Saw used for sawing column stock.

19 gives 3.16, the number of seconds required for sawing each square inch of cross-sectional area. Our column has a cross sectional area of 2.4 square inches. The machining time for the operation of sawing will be 2.4 x 3.16=7.6 seconds.

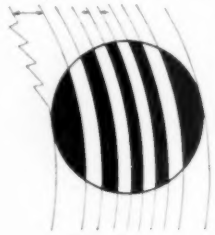


Fig. 5.

The areas of all the shaded portions are equal. This shows that the number of cu. in. of metal removed by hydraulic feed is the same per minute throughout the cross section of the bar.

The estimated time for reloading the machine for the next column is 7½ seconds, making the floor to floor time for the operation 7.6 + 7.5 = 15.1 seconds. To arrive at the production per hour, we divide 3600 seconds by 15.1, giving 238 pieces per hour. Owing to human inefficiency, breakdowns, and other contingencies, such a production cannot be counted upon. Therefore we deduct 15 per cent from our calculated production as a margin of safety. This course will be followed throughout this paper in computing production figures. The corrected figure for our production on the cut-off machine will then be 238 x 85 per cent = 202 pieces per hour.

The graph in Fig. 6 represents the machine loading of the cut-off saw. This form of chart was used for all production machines in the plant. In the graph, the ordinate represents the hours of the day that the machine operates, and the abscissa the number of parts for intermittent periods of time when columns and spindles are cut off. The graph shows that the operator and machine have three hours available for other work.

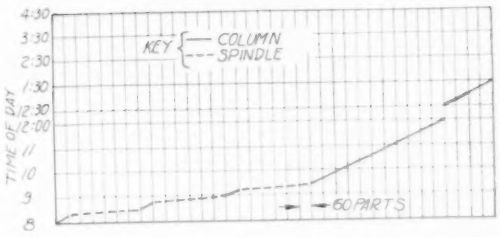



Fig. 6. Machine Load graph for Cut-off Saw.

In the second operation, drill spotting, the actual machining is so slight that an estimate of 3 seconds was arrived at for the machining time. The Canedy-Otto Drill Press shown in Fig. 7 is adequate for such a light operation, and gives a sufficient production, so that the use of a more expensive machine would not be justified. By going through the motions of the operator, 7 seconds was set up a reasonable floor to floor (more properly, "bench to bench") time. Dividing 3600 seconds by 7 gives us a production of 514 parts per hour. Deducting the usual 15 per cent for inefficiency, the corrected production becomes 437 per hour. This number of parts is not the actual output, however, as the cut-off saw operator performs this operation, and has just time enough to spot-drill a column while the saw is taking a cut.

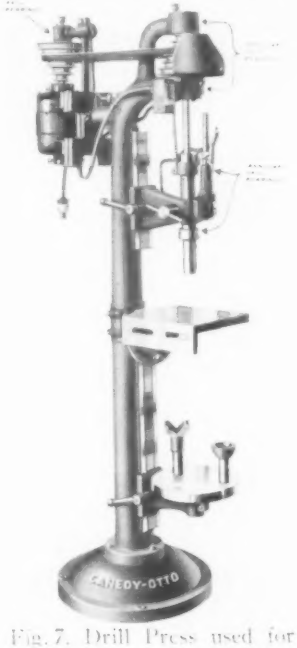



Fig. 7. Drill Press used for second operation on Column.

The jig used for this operation is shown in Fig. 8. The part is placed in the Vee C, abutting against the adjustable screw A, and is held by the operator with one hand while with his other hand he lowers the drill through bushing B to a stop collar on the drill press spindle.

A Cincinnati centerless grinder, shown in Fig. 9, is used for the third operation. The machine is equipped with an automatic Danly feeding hopper and an electrically controlled hydraulic wheel adjustment for maintaining a uniform diameter on the work.

The average metal removing capacity of a centerless grinder is 1 cubic inch per minute per 10 horsepower applied, from which the following formula is derived:

$$T = \frac{V \times 60 \text{ seconds} \times 10}{HP. \times 85\%},$$

$$T = \frac{706\ V}{HP.},$$

where T is the time in seconds, V the volume in cu. in. of metal removed, and HP. the horsepower of the machine. The 15 per cent. power lost in transmission from the motor to the work is taken account of in the formula. The time required for grinding the column is found by substituting the values for V and HP. in the formula.

$$T = \frac{706 \times 0.504}{HP.} = 24 \text{ seconds.}$$

The production per hour will be 3600 ÷ 24 = 150 pieces per hour. In this case there will be no 15 per cent deduction for inefficiency, as the centerless grinder is automatic, the parts being fed into the machine by a hopper.

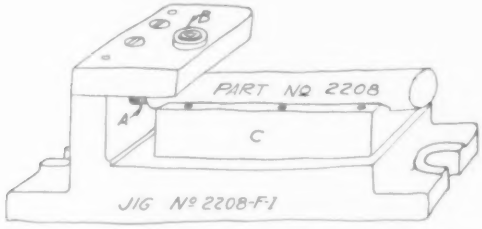



Fig. 8. Fixture for Drill Spotting Column.

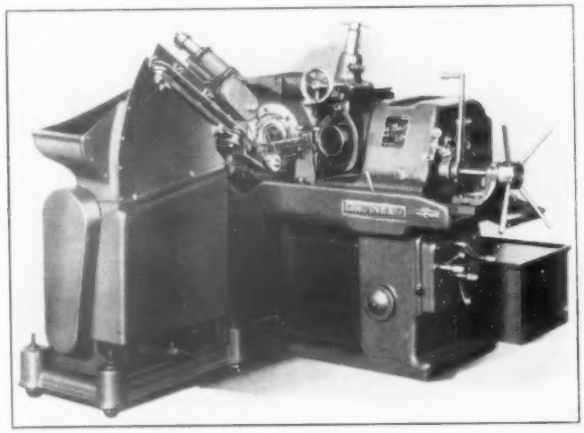


Fig. 9. Cincinnati Centerless Grinder for third operation on column.

Grinding by this method gives an accuracy of ±0.0005" in one pass. The ratio of the amount of metal removed to abrasive worn off is about 12 to 1 for steel. On this consideration we based the number of wheels required in one year.

The feed (f) in inches per minute of the work through the grinder is determined by the diameter of the feed regulating wheel and the angle at which this wheel is set to a perpendicular to the axis of the grinding wheel. The following formula is used:

f=pi D x R.P.M. (of regulating wheel) x sin A

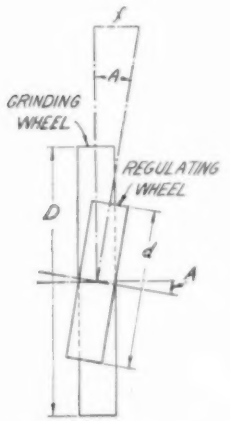



Fig. 10. Determination of feed of work (f) through centerless grinder.

Fig. 10 illustrates.

Operation No. 4 is burring. The amount of metal removed in this operation is slight, and 8 seconds was estimated as the floor to floor time. Production will be 3600 : 8 x 85 per cent or 382 pieces per hour. Fig. 11 shows the machine, a Sebastian Engine Lathe.

The fixture used for burring the column is shown in Fig. 12. It is

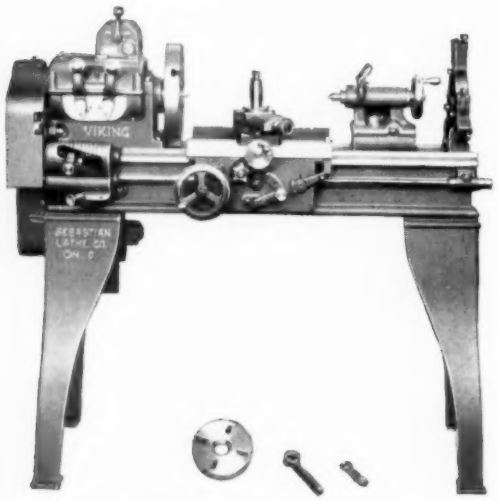



Fig. 11. Engine Lathe for burring end of column.

mounted on the carriage of the engine lathe from which the tailstock has been removed. The bars come from the centerless grinder down the chute A which empties them into the fixture. The operator stands at the front of the lathe, and locks the column B in the fixture by exerting an upward pressure on the lever C, which clamps the work at F by means of a cam action similar to that employed in an over-running clutch. He feeds the

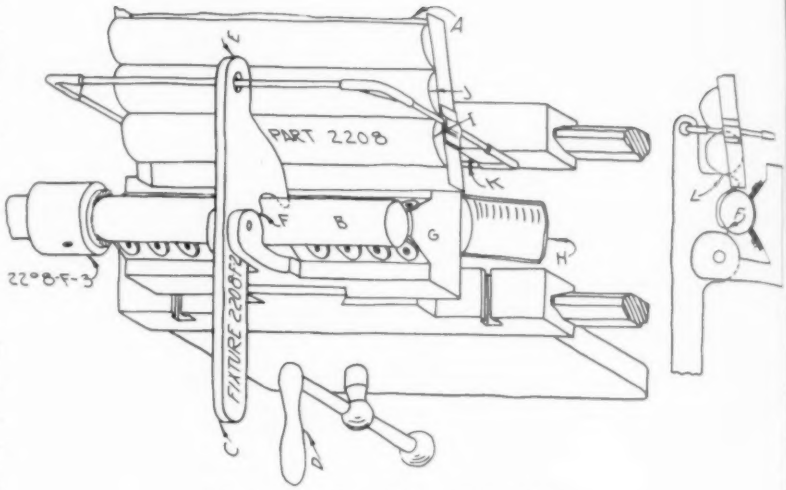



Fig. 12. Fixture for Burring Column.

fixture toward the headstock by turning the handle D. The downward pressure on E forces the projection F against the work to keep it from revolving. As the end E of the clamp is lifted, the part B, which rests on the rolls G, slides toward the tailstock end of the lathe and down the chute H, a spring actuated knockout rod located in the headstock spindle ejecting the parts. As the end E is lifted farther, the column I rolls out of the chute A into the fixture, and the column J stops against the plate K where it rests, until the clamp is returned to the position shown, allowing it to roll to position I.

The fifth operation, performed on the machine shown in Fig. 13, is tap drilling. A feed of 0.012" per revolution and 614 rpm. was used. To find the machining time we use the simple formula:

$$T = \frac{60 \times L}{N \times F},$$

where T is the time in seconds, L the depth of the hole, N the number of revolutions per minute, and F the feed per revolution.

$$T = \frac{60 \times 1\frac{1}{8}}{614 \times 0.012} = 9 \text{ seconds.}$$

Allowing 3 seconds for loading and unloading the fixture, the floor to floor time is 12 seconds. The output will be 3600 : 12 x .85 = 255 parts per hour.

The jig used for this operation is shown in Fig. 14. The operator places the column in the hardened vees at A, the bottom resting on the hardened button D, and with the cam-locking clamp B holds the column in place. With his other hand he lowers the drill through the bushing at C to a stop collar on the drill press spindle.

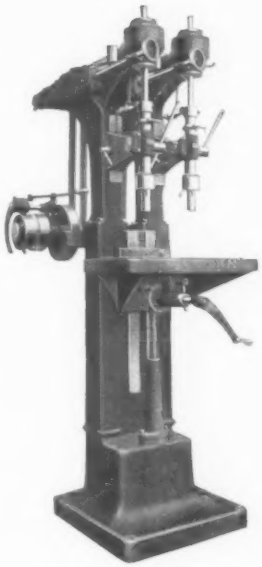


Fig. 13. Avey Drill Press used for tap drilling column.

The sixth operation, performed on the machine shown in Fig. 15, is tapping. We used a cutting speed of 20 ft. per minute. The mean diameter of a 3/8-16 tap is 11/32", circumference 1.08". Sixteen threads must be engaged to thread 3/4" depth of full threads.

$$\text{R.P.M of tap} = \frac{20 \times 12}{1.08} = 222.$$

The number of revolutions required is 1⅛ (total depth) x 16 = 18.

$$T = \frac{18 \times 60}{222} = 5 \text{ seconds.}$$

Adding 3 seconds to reverse the tap, the total time is 5 + 3 = 8 seconds. The output will be 3600 ÷ 8 x .85 = 362 pieces per hour.

The same type jig (minus the bushing plate), used for the preceding operation of tap drilling is used for tapping.

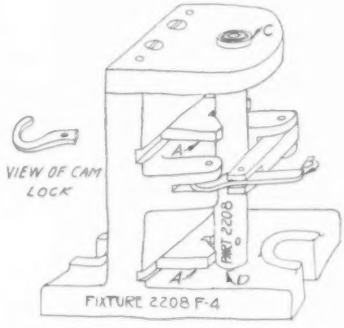



Fig. 14. Fixture used for tap drilling column.

Fig. 17 shows the operation and data sheet for the column. Data sheets exactly similar to this were made up for each of the remaining details of the drill press, as also were gage data sheets. It will be noted that the data sheets carry columns for machine hour rates, wage rates, direct labor costs, and tooling efficiencies. The determination of these items will be described fully in the section of this paper entitled Cost Analysis. All the other column headings in the data sheet shown are self-explanatory.

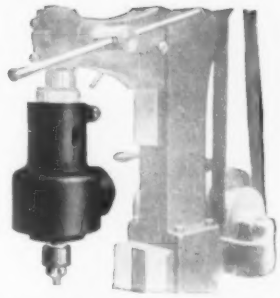


Fig. 15. Avey Tapper used for tapping column.

## OPERATION SEQUENCE, DETERMINATION OF OPERATION TIMES, AND FIXTURE DESIGN FOR BASE

The first operation on the cast iron base (Fig. 16) is to disc grind the bottom face. The machine is shown in Fig. 18. No fixture is used, as the operator presses the part against the grinding wheel by hand. It is necessary to remove only a slight amount of metal, just enough to smooth the surface, so that 15 seconds is an ample floor to floor time allowance on this operation. This gives a production of 4 a minute, which is almost twice the production required, enabling the same operator to perform the second operation, drilling the four 13/32" holes.

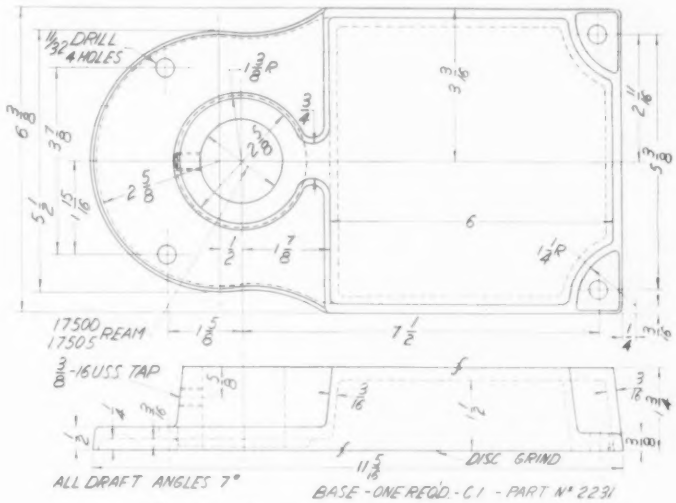



Fig. 16. Base of the Drill Press.

## TOOL DATA SHEET

PART NAME—COLUMN | PRODUCTION—1000 PER DAY | PART Nº 2208

| OPERATION Nº | OPERATION NAME | ESTIMATED TIME IN SEC. CUTTING TIME | FLOOR TO FLOOR | PARTS PER HOUR | DEPT. | MACHINE Nº | MACHINE NAME | COST | H.P. | R.P.M. | FLOOR SPACE | STD. MACHINE EQUIPT. NAME | UNIT COST | TOTAL COST | STANDARD PERISHABLE TOOLS NAME | Nº REQ'D PER YR. | ESTIMATED LIFE | UNIT COST | TOTAL COST | SPECIAL PERISHABLE TOOLS NAME | Nº REQ'D PER YR. | EST. LIFE | UNIT COST | TOTAL COST | SPECIAL FIXTURES FIXTURE Nº | UNIT COST | TOTAL COST | MACH. HOUR RATE | LABOR RATE PER HR. | INDIRECT MACHINE COST | DIRECT LABOR COST | TOOLING EFFICIENCY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CUT OFF | 76 | 15.1 | 202 | A | 1 | WAGNER BIR-CUT OFF SAW | $1500.00 | 3 | 1800 | 40 X 36 | SAW BODY | $36.00 2 REQ'D | $72.00 | SAW TOOTH BLADES | 5 SETS OF 56 TEETH | 60,000 PIECES | $.47 | $26.60 | NONE | NONE | NONE | NONE | NONE | NONE | NONE | NONE | $2.86 | $.70 | $.00598 | $.00148 | 50% |
| 2 | DRILL SPOT | 3 | 7 | 202 | A | 2 | CANEDY-OTTO 14" SENSITIVE DRILL PRESS | 120.00 | 1/4 | 1800 | 20 X 24 | NONE | NONE | NONE | 5/16" H.S.S. Nº1 M.T. DRILL, BRINEY BUSHING Nº 3A | 6 / 5 | 50,000 | .78 / 1.50 | 4.68 / 7.50 | NONE | NONE | NONE | NONE | NONE | 2208-F1 | $25.00 | $25.00 | 3.64 | .70 | .0015 | .00064 | 43% |
| 3 | GRIND | 24 | 24 | 150 | A | 3 | Nº2 CINCINNATI CENTERLESS GRINDER | 4700.00 | 15 | 1200 | 55 X 90 | WORK REST, SIZER, MOTOR, FEED WHEEL, | 250.00 750.00 300.00 40.00 | 1340.00 | ALOXITE ABRASIVE WHEEL 20" DIA. X 8" X 12" | 9 | 38,200 | 60.00 | 540.00 | NONE | NONE | NONE | NONE | NONE | NONE | NONE | NONE | 3.08 | .57 | .0064 | .00013 | 100% |
| 4 | BURR | 5 | 8 | 382 | A | 4 | 12" SEBASTIAN LATHE | 870.00 | 1 | 1200 | 18 X 60 | NONE | NONE | NONE | NONE | NONE | NONE | NONE | NONE | 2208-T1 | 5 | 60,000 | 12.00 | 60.00 | 2208-F2 | 100.00 | 100.00 | 2.60 | .57 | .0260 | .00041 | 62 1/4% |
| 5 | DRILL HOLE | 9 | 12 | 255 | A | 5 | Nº1 AVEY DRILL PRESS | 550.00 | 1 | 1800 | 15 X 26 | NONE | NONE | NONE | 5/16" H.S.S. Nº2 M.T. DRILL, BRINEY BUSHING Nº 3A | 12 / 5 | 34,000 / 60,000 | .78 / 1.50 | 9.36 / 7.50 | NONE | NONE | NONE | NONE | NONE | 2208-F3 | $25.00 | $25.00 | 1.36 | .57 | .00339 | .00092 | 75% |
| 6 | TAP HOLE | 5 | 8 | 362 | A | 6 | Nº1 AVEY TAPPER | 700.00 | 1 | 1800 | 15 X 26 | FRICTION CHUCK | 35.00 | 35.00 | 3/8-16 U.S.S. TAP H.S.S. | 12 | 30,000 | .25 | 3.00 | NONE | NONE | NONE | NONE | NONE | 2208-F3 LESS BUSH PLATE | 75.00 | 75.00 | 1.99 | .57 | .00275 | .00043 | 62 1/4% |
| TOTALS | | | | | | | | 8440.00 | | | | | | 1447.00 | | | | | 203.64 | | | | | 60.00 | | | 425.00 | | | .03781 | .00401 | |
| MATERIAL-C.R.S.- COST-$.196 | | | | | | | | | | | | TOTAL FACTORY COST OF PART- $.24178 | | | | | | | | | | | | | | | AVERAGE EFFICIENCY | | | | | 65.4% |

Fig. 17. Operation and Data Sheet for Column of Drill Press.

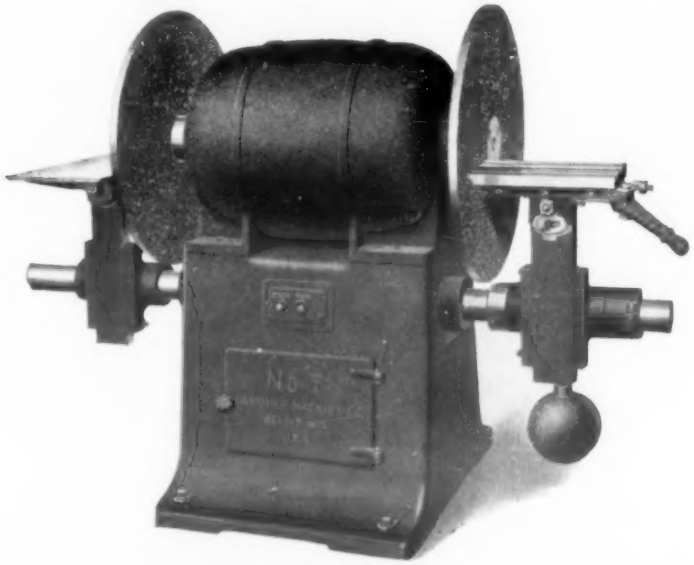


Fig. 18. Gardner Disc Grinder used for Grinding bottom of Base.

A four spindle multi-head fixture (Fig. 19) is used for this operation. The part is put in the fixture and approximately located against the adjustable screw A and the pins B. As the multi-head descends, the column hole boss on the part is clamped at three points by the ring C. The spring actuated plunger D, which is attached to the underside of the suspended bushing plate, presses the base against screw A.

*(Continued Next Issue.)*

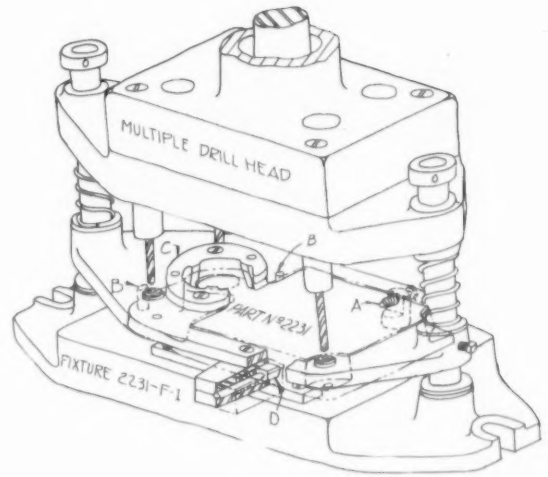
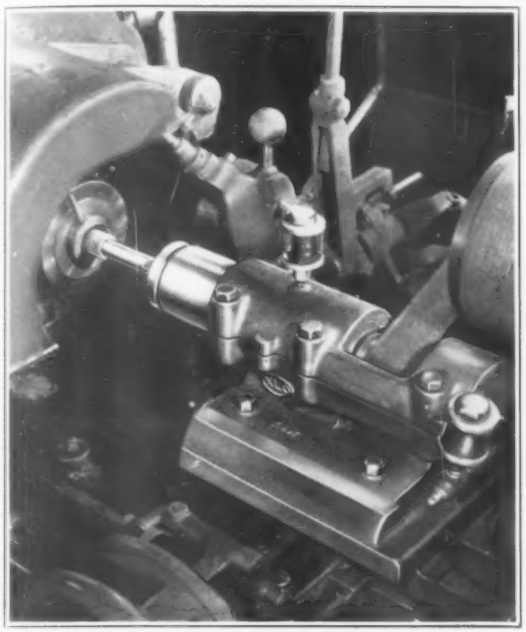



Fig. 19. Multi-Head Jig used for drilling four 11/32" holes in Base.

# Ex-Cell-O Internal Grinding Spindles



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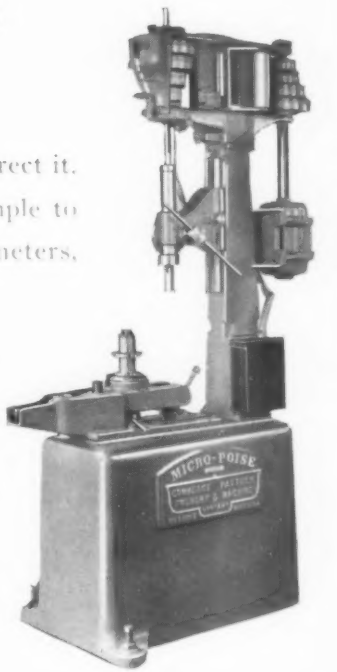


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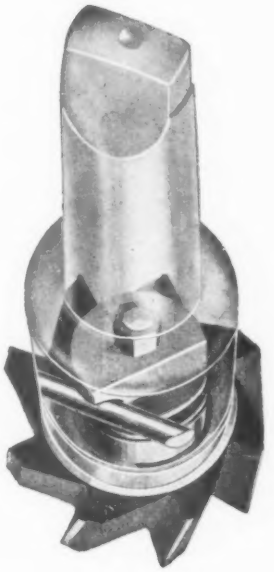

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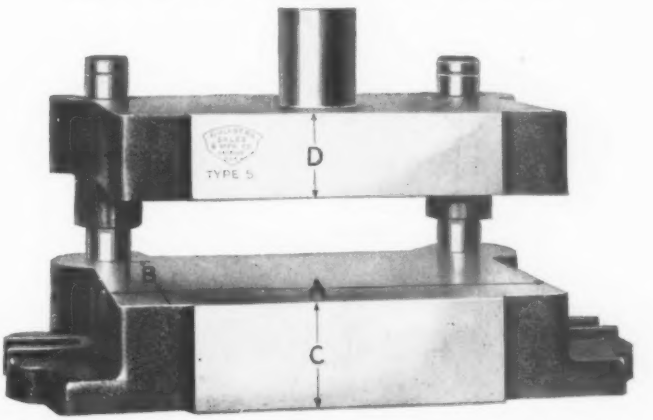


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